PFA Algorithm

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A Particle Flow Algorithm (PFA) for GLD detector has been developed in order to get better jet energy resolution. We studied the PFA using the GEANT4-based full simulator named Jupiter. In this paper, details of each method in PFA are presented. Current problem in the PFA and future prospects are also discussed.

1. INTRODUCTION

There is a general consensus that Particle Flow Algorithm (PFA) derives overall ILC detector design. Three detector concepts have been proposed so far [1] and these detectors should be optimized by using a PFA. The GLD detector that has a large inner radius of the calorimeter is one of them. A PFA for the GLD detector has been developed and studied by using the GEANT4-based full simulator named Jupiter. General scheme and performance of the GLD-PFA are presented in [1]. In this paper, details of each method in the PFA, the gamma finding and track matching, are presented. There were a lot of discussions during the Snowmass workshop in order to improve the PFA. Current problems in the PFA and future prospects are also discussed in this paper.

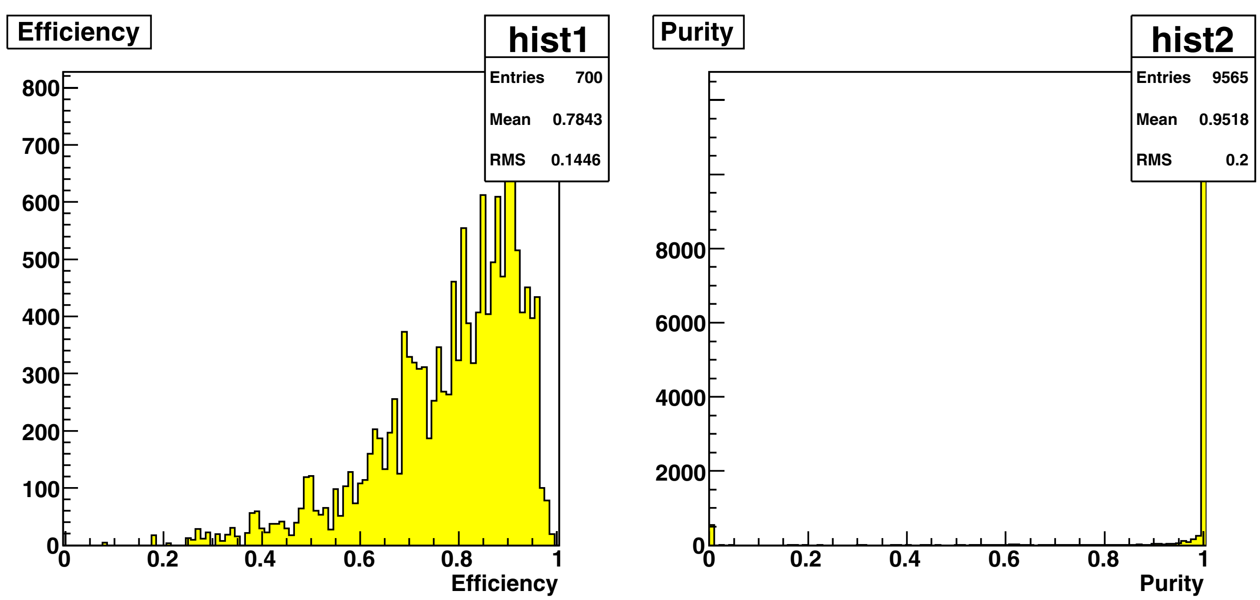

Figure 1: Performance of the gamma finding method; energy-weighted efficiency (left) and purity (right).

[1] A fourth concept was proposed during the Snowmass workshop.

2. GAMMA FINDING

The gamma finding procedure is as follows: First of all, relatively large small cluster (called "mother small cluster") within electromagnetic calorimeter (ECAL) region is searched among the small clusters [2]. In the next, a cut on distance from the mother small cluster to the nearest charged track is applied. Here the nearest charged track means the "extrapolated charged track" to the ECAL. Small clusters around a mother small clusters are then collected to form a gamma cluster. Finally, several cuts on longitudinal shower profile of the gamma cluster are imposed. More details of the gamma finding method can be found in [2]. Figure 1 shows the performance of the gamma finding method. Left (right) histogram shows the energy-weighted efficiency (purity) for the gamma finding method and obtained to be 78.4% (95.2%).

3. TRACK MATCHING

Figure 2 illustrates the track matching method. The basic concept of the track matching method is to extrapolate a charged track to the calorimeter and calculate distance between a calorimeter hit cell and the extrapolated track. The calorimeter hit cells within a certain tube radius are connected to form a charged hadron cluster. The distance is calculated for any track/calorimeter cell combination. Note that the tube radius for the ECAL and HCAL can be changed separately. Current tube radius is set to be 20 cm and 40 cm for ECAL and HCAL, respectively. Figure 3 shows the performance of the track matching method. Left (right) histogram shows the energy-weighted efficiency (purity) for the gamma finding method and obtained to be 84.2% (91.2%). Note that contribution from the neutral hadrons are subtracted for the purity calculation.

4. DISCUSSION

The PFA-GLD performance is studied by using $Z \to q\bar{q}$ events, and jet energy resolution of $40\%/\sqrt{E}$ is achieved with reasonable segmentation (cell size for ECAL is 4 cm $\times$ 4 cm and for HCAL is 12 cm $\times$ 12 cm) [1]. There was a discussion about worse resolution of the calorimeter sum energy ($60\%/\sqrt{E}$). So far, a constant calibration factor

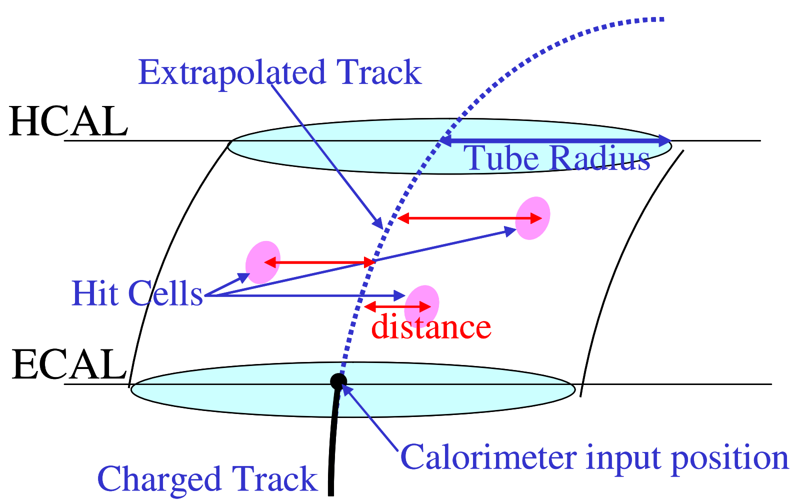

Figure 2: Illustration of the track matching. See text for more details.

[2] In prior to the gamma finding, the nearest neighbor clustering (small clustering) is performed as described in [1].

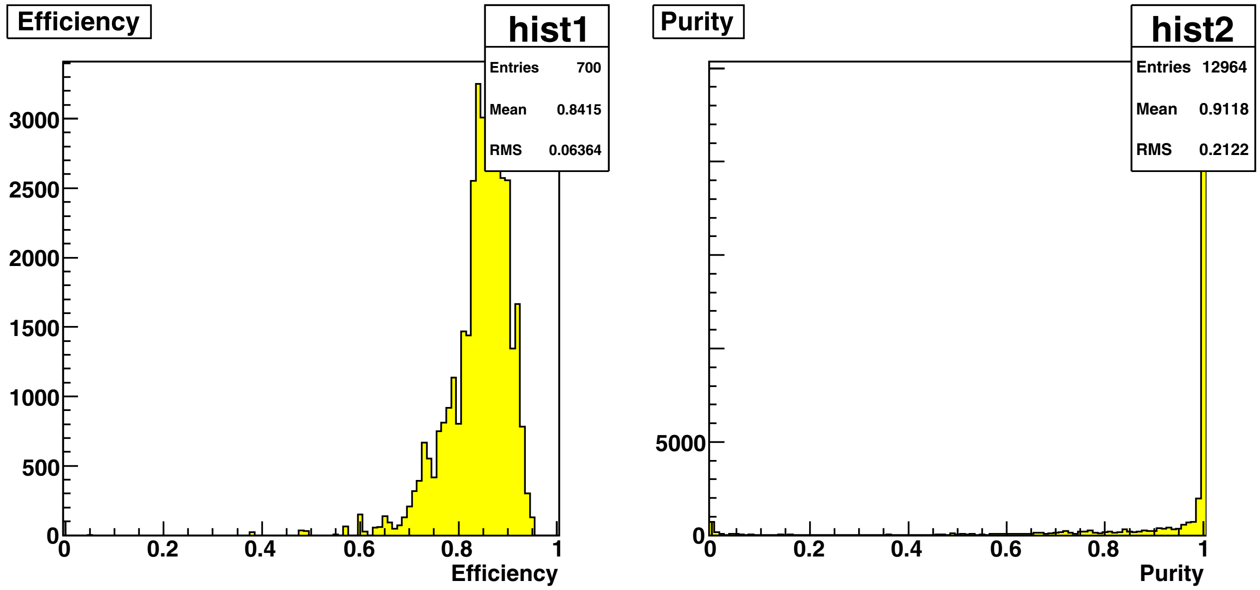

Figure 3: Performance of the track matching method; energy-weighted efficiency (left) and purity (right).

was used in order to convert to actual energy from visible energy deposit. It was pointed out that energy dependent calibration factor should be applied. By looking at distribution of a small cluster energy subtracted by true cluster energy, it turned out that current small clustering method tends to merge two (or more) particles. In order to obtain the energy dependent calibration factor, we might therefore need to improve the small clustering method.

The calorimeter granularity dependence is also studied as described in [1]. So far, no significant gain can be seen with finer segmentation. It was suggested that to try higher center of mass energy to see granularity dependence. In addition to that another algorithm (pattern recognition, etc.) might be used for finer segmentation.

There is also a discussion about the current track matching performance. It turned out that track matching purity for the endcap region is low. The track matching method should be improved for the endcap region, in particular for low momentum case.

There were a lot of discussions about future prospects in addition to the above: The material study should be performed as well as the granularity study. The MIP finding method and neutral finding method should be implemented in near future.

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References

[1] T. Yoshioka, “Particle Flow Algorithm for GLD”, in these Proceedings.
[2] T. Fujikawa, “Photon Finding Procedure for GLD-PFA”, in these Proceedings.